Technology Demonstration Fact Sheet

Liquid Nitrogen-Cooled Diamond-Wire Concrete Cutter

SUMMARY

The Hanford Site C Reactor Technology Demonstration Group demonstrated a Liquid Nitrogen-Cooled Diamond-Wire Concrete Cutter developed by Bluegrass Bit Company, Inc. (Greenville, AL). The Bluegrass Liquid Nitrogen-Cooled Diamond-Wire Concrete Cutter can cut through reinforced concrete and rebars. This innovative technology can cut through thick concrete walls and structures dry and does not require wire cooling with water. The diamond-wire is cooled externally with liquid nitrogen.

During this demonstration this innovative technology was used to cut through a 12-ft high and 3-ft thick reinforced concrete wall containing rebar size ranging from 7/8" to 1". The innovative technology successfully cut through over 3/4 of the wall without using any water for cooling the wire. Only a small amount of liquid nitrogen was used to cool the diamond wire. By using this method of cutting concrete, no liquid waste was generated. The dry dust produced was contained in a temporary enclosure that was vented via a vacuum HEPA filtration system.

For decommissioning and decontamination (D&D) projects, the Bluegrass Liquid Nitrogen-Cooled Diamond-Wire Concrete Cutter can be used for both radiological and non-radiological thick concrete cutting. The demonstration was done to challenge the baseline technology of cutting thick concrete walls and floors (structures) containing rebar using water-cooled wire saws and circular saws.

Comparisons and results of the innovative technology demonstration versus the baseline demonstration were as follows:

- No applied cooling water and liquid waste generation
- Produces dry dust waste
- Increased operator safety/ALARA versus circular saw
- Slower cutting time than the baseline methods
- More wire wear versus water-cooled wire.

INNOVATIVE TECHNOLOGY DESCRIPTION

The Bluegrass Liquid Nitrogen-Cooled Diamond-Wire Concrete Cutter can cut through thick concrete walls, floors, and structures dry, and does not require water cooling. With the innovative technology, the diamond wire saw is cooled with liquid nitrogen applied in a 3- foot long by 3-inch diameter pipe. The diamond wire saw is pulled through the pipe to cool the wire. The innovative Liquid Nitrogen-Cooled Diamond-Wire Concrete Cutter consists of the following components and features:

- A 50-horsepower hydraulic pump that requires 60-amp 440VAC electric power. The pump can provide up to 1500 psi pressure. The hydraulic fluid used by this pump is a non-hazardous vegetable oil-based fluid.
- A Shar-Lyne hydraulic motor that powers the diamond-wire saw-drive wheel.
- A 3-ft-diameter drive wheel that generates wire tension and moves the diamond wire. The wheel can move the diamond wire as fast as 10 ft/s. The speed and tension on the diamond wire saw are controlled by adjusting a cylinder valve and a needle valve on the hydraulic pump, respectively.
- A compound guide-pulley system for guiding the diamond wire.
- A liquid-nitrogen applicator located at the slack side of the diamond wire. The nitrogen is applied from a pair of tubes that are above the wire. The liquid nitrogen is supplied by an approximately 200-liter, liquid nitrogen bottle that is commercially available. The liquid nitrogen consumption rate during the concrete cutting, manually controlled at approximately 50 psig pressure, is approximately 50 liter/hour.
- Diamond wire assembled by the Bluegrass Bit Company, Inc. The diamond wire is made of 1/4" aircraft-quality steel cable running through a series of diamond-impregnated beads made by TruCo. Each diamond-impregnated bead is separated from the next by a spring, and every three-bead/spring combination is separated by an 8,000-lb-pressure brass crimp.

The demonstration was conducted on an uncontaminated 12-ft high and 3-ft thick reinforced concrete wall with rebar size ranging from 7/8" to 1". To perform the cut two 2"-diameter holes were drilled at the top and bottom of the walls. Then the diamond wire was threaded through the walls and the drive wheel, guide pulleys, and liquid nitrogen. The ends of the diamond wire were joined using the crimp. Once the tension was adjusted the drive wheel was started at slow speed, and gradually saw speed was increased to reach to the optimum speed. The speed and the tension on the diamond wire were controlled by one operator and the liquid nitrogen application was controlled by a second operator. A small amount of liquid nitrogen was used to cool the diamond wire. Although this method of cutting concrete creates no liquid waste, the dry cutting generates dust. In order to assess filter loadings that would be encountered cutting a contaminated wall, a small, temporary enclosure (7' wide x 18' long and 13' high) was erected around the saw and the concrete cutting area and exhausted via a HEPA filtration unit. The hydraulic power unit and controls were located outside of the enclosure. (Other precautions would be taken for contaminated cutting such as continuous air monitoring and use of appropriate PPE.) The oxygen level inside the enclosure was monitored due to the liquid nitrogen evaporation and displacement of oxygen.

Performance figures (crew of two operators for cutting ~ 9 ft of a 3-ft thick wall):

- Initial saw setup time 1½ hr
- Wall holes (2) drilling time 2 hr
- Cutting time for wall (nitrogen cooled) 3hr 18min
- Time to remove the saw ½ hr

BASELINE TECHNOLOGY DESCRIPTION

The baseline tools are a conventional water-cooled diamond-wire and concrete wall saws. The wall saw also uses a hydraulic drive power system to run the saw. The wall saw is track mounted and uses a 26"-diameter blade, making it possible to cut as deep as 12". To use the wall saw a track is installed on the concrete surface that is being cut to guide the saw during the cutting process. The track is normally held down to concrete surfaces by three anchor bolts per 10-ft section of track. The wall saw cuts to 4" per pass. For cutting thick concrete with this saw it is necessary to make multiple passes. For concrete thicker than 12" cuts are made on each side of the concrete wall opposite of each other. The baseline saws are also capable of cutting through rebar. All walls cut had little or no rebar in the center 2ft. For the baseline demonstration, 12"-deep cuts were made on two sides of a 3-ft thick wall and the remaining uncut 12" was sheared by battering the wall with a hoe-ram. Both the baseline diamond wire and the circular saw blade require continuous water cooling during the cut. The circular saw is equipped with a shroud that is used both for dust dispersion control and as a safety guard.

Comparison to Baseline

Technology Type	**Innovative**	**Baseline Diamond Wire (water cooled)**	**Baseline Circular Saw (water cooled)**
Wall Size (rebar)	3' x 12' (#8 & #10)	Same as Innovative	3' x 40' Part face cut 1' deep (#8 & #10)
Set Up Time	2hr 2 people	2 hr 2 people	6 hr (on each side of the wall) 3 people
Production Cutting Rate ft 2 /min ***	.14	.20	.08
Wastewater gal/ft^2	None*	3	3
ALARA	Saw can be remote up to 200'	Saw can be remote up to 200'	Operator near location of cut
Safety	• O2 depletion • Danger if wire breaks	Danger if wire breaks	Saw is heavy to set on track
Enclosure**	Required	None	None

* The innovative saw is capable of using water for cooling the diamond wire.

** The innovative saw is capable of using small amounts of water for dust control, in which event no enclosure would be required.

** * Saw cuts are quantified in terms of area of the face cut. For example, a 3-ft thick, 12-ft high wall, cut is 36 ft^2.

DETAILS OF BENEFITS

The innovative saw system has these benefits:

- Relatively easy to set up
- Short setup time
- No need for multiple setups to cut a thick concrete structure
- No cooling water for the saw, so no secondary liquid waste.

DRAW BACKS

- Liquid nitrogen can cause frost injuries and asphyxiation
- Generation of large amount of dust
- Need large HEPA filtration system.

SUCCESS CRITERIA

- Maneuverability around/over interferences for setting in place
- Simple to deploy
- Similar cutting rate but better setup time than the baseline circular saw
- Better precision cut than baseline circular saw (no double cutting).

SCHEDULE

The innovative technology demonstration was conducted at C Reactor March 23-31, 1998.

FUTURE APPLICABILITY

The Liquid Nitrogen-Cooled Diamond-Wire Concrete Cutter system such as the one demonstrated can best be used for cutting contaminated or non-contaminated thick concrete. Potential applications at C Reactor would include all the residual walls that need precision cutting for an interim safe storage condition, along with concrete cutting required at the fuel storage basin. The demonstration unit was leased including the system operators (two persons). This innovative system could be used at sites performing D&D activities that include thick concrete cutting, in both the private and government (DOE, EPA, DOD, etc.) sectors, especially where there is incentive to avoid liquid contaminated waste.

The innovative system suffered from wire overheating during the latter part of the cut. The system could be improved by totally submerging the wire in liquid nitrogen instead of applying liquid from above the wire, or by also applying liquid nitrogen directly into the saw kerf.

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